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A COMPARISON STUDY OF NOISE LEVELS ON STEEL RAILWAY BRIDGE

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Abstract. *With the recent advent of high-speed rail, railways brought about new technological advances resulting in the improvement of traffic convenience and reduction in transport time, and they have made a significant contribution to regional development and rise in the standard of living. However, the improvement of living standards led to an increase in the desire for a pleasant environment. As railroads situated on the outskirts of the city was located to the city center, the problems of vibration and noise according to the three-dimensional utilization of the railway tracks due to the effects of previously constructed roads have emerged as environmental issues of the surrounding area and riding environment. In this regard, this paper was designed to establish methods for noise reduction on the railroad that passes through railway bridge and surroundings of railway bridge that goes all the way across the city center due to the impact of urban roads. Towards this end, noise characteristics were investigated when a train passes through the steel bridge frequently applied among bridge structures, and the measured distance and speed by vehicle type were analyzed. Research results showed that the average nose level in the line side of the steel bridge was measured at 102dB, and the average noise attenuation was 3.7dB.*

1 INTRODUCTION

With the recent advent of high-speed rail, railways brought about new technological advances, and they have made a significant contribution to balanced regional development and rise in the standard of living through the improvement of traffic convenience and reduction in transport time. However, as the improvement of living standards met the basic needs for food, clothing and shelter, and it furthermore led to an increase in the desire for a pleasant environment. In case of the railways, the problem of noise has emerged as environmental issues of the surrounding area and riding environment. Due to the expansion of the city resulting from the increase of the urban population, railroads situated on the outskirts of the city was located to the city center, and railway tracks tend to become three-dimensional into the underground or above ground. The impact of urban roads led to construction of overpass railroads. Accordingly, it is required to conduct accurate noise prediction and analysis in consideration of the site conditions for establishment of methods for noise reduction on the railroad that passes through overpass railway bridge and surroundings of railway bridge that goes all the way across the city center.

In this paper, the steel railway bridge of the terrain where the problem of bridge noise occurs or area with potential noise problem was selected, and noise characteristics were investigated when a train passes through the steel railway bridge. Based on the results, the measured distance of noise sources and speed by vehicle type were analyzed, and noise prediction equation was presented using the analysis results.

2 EXISTING RESEARCH TRENDS OF NOISE

Seok-Hong Kim et al.(1993) analyzed noise and vibration time-varying characteristics of the existing railways, distance attenuation characteristics, frequency characteristics and directional characteristics of railway vibration in “a study on the characteristics of railroad noise and vibration propagation in Kyoungbu Line’, and Dae-Joon Gang(1997) conducted a research to deduce the prediction equation that can calculate equivalent noise levels of the surrounding area by estimating the highest noise level from the train speed, and to utilize its results in the revision of measurement methods. J.G. Walker et al. (1996) predicted design factors of low-noise bridges using a finite element method (FEM) and compared the noise levels measured from the actual overpass bridge with theoretical values to reduce the noise of overpass structures in “An Investigation of Noise from Train on Bridge”. In these studies, an analysis of noise and vibration characteristics, deduction of a prediction equation and a comparative study of theoretical and experimental values using the FEM were carried out. However, since railway noise arises from many complex factors such as moving vehicles and interaction with tracks to support them, technology accumulation and researches on the multi-faceted aspects of vehicles, tracks, track supporting structures and ground should precede establishment of countermeasures. In case of a railway that passes through the surroundings of downtown or residential areas, the secondary noise sources due to structure borne noise caused by structures (overpass structures or bridges) supporting tracks have worsened the ambient noise problem. Accordingly, it is urgently required to take measures against the ambient noise propagation by trains that pass through the overpass structures unlike noise arising from the general railway system.

3 NOISE MEASUREMENT METHODS

This study attempted to figure out the actual status of noise levels on steel railway bridges operated in Korea and propagation characteristics by measuring the size of noise sources and propagation characteristics. For noise measurement, target areas were divided into the terrain with the problem of bridge noise and potential problem area, and each of the 2-4 areas were selected as representative locations respectively. A measurement was performed at 2-8 positions by distance from the center of tracks depending on the surrounding environment at each measurement point. Railway noise levels vary depending on the kind of a train, length of the train, transit time, track conditions, operating conditions (acceleration, constant speed, and deceleration), repair state of the train and rail and kind of a bridge. In surveyed area with good measurement environment, noise levels by distance of individual trains were measured, and noise analysis results were displayed. <Table 1> shows 1-hour equivalent nose levels of measurement area. Noise levels varied from 63 to 86dB(A) depending on the distance and height. These values were obtained from the measurement in tracks and surroundings of roads, and noise levels of 64～70dB(A) were measured in residential areas.

No.	Line	Area	Terrain classification	Distance(m)	Equivalent noise level (1h, dB(A))	Remark
1	Ansan Line	Geumjeong bridge1	Concrete bridge	45 (11 F)	67	Apartment
2	Ansan Line	Geumjeong bridge2	Concrete bridge	27 (10 F)	70	Apartment
3	Ansan Line	Geumjeong bridge3	Concrete bridge	42 (10 F)	69	Apartment
4	Ansan Line	Geumjeong bridge4	Steel composite bridge	78	69	Vacant land
5	Daejeon Line	Ojeong bridge1	Steel composite bridge	42.5	64	House
6	Daejeon Line	Ojeong bridge2	Concrete bridge	25	74	Field
7	Kyongbu Line	Geumgang 1st bridge	Steel bridge	25	80	Bridge substructure
8	Jungang Line	Wonjucheon bridge	Steel bridge	50	74	River floodplain
9	Kyongbu Line	Mihocheon bridge1	Steel bridge	150	63	River floodplain
10	Kyongbu Line	Mihocheon bridge2	Steel bridge	100	69	Field

Table 1 : Equivalent noise levels of survey area

In this study, ambient noise by distance was measured from a total of four steel railway bridges in measurement areas of Geumgang 1st Bridge in Kyongbu Line, Wonjucheon Bridge in Jungang Line, and Mihocehon Bridge in Kyongbu Line. Figure 1 and 2 show the representative measurement scenes from steel railway bridges, and area-specific noise by distance was measured as shown in Figure 3.

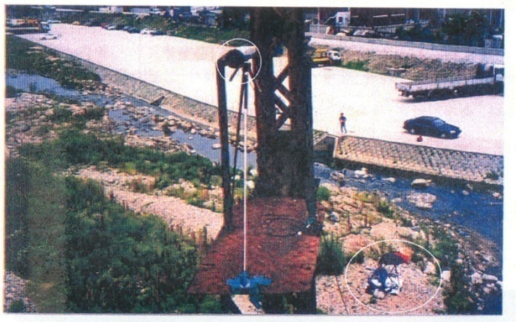


Figure 1: Measurement by distance of line side

Figure 2: View of a train that passes through the measurement location

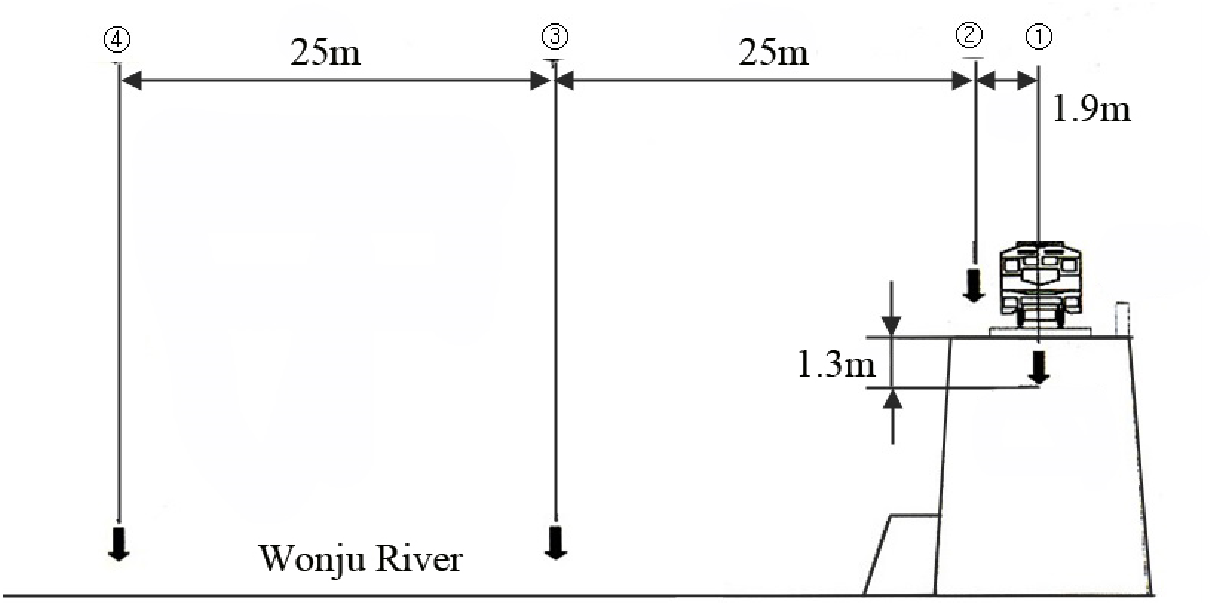


Figure 3: Measurement of the ambient noise by distance

4 ANALYSIS OF NOSE CHARACTERISTICS

Table 2 shows values of noise levels measured by vehicle type and distance of steel railway bridges, and noise attenuation is shown in Table 3. From the measurement results of steel bridges, the biggest nose level was found in Wonjucheon Bridge, and Mihocheon Bridge showed low noise level.

Vehicle type	Location	Average speed Km/h	Measurement results by distance dB(A)				
			2.5m	25m	50m	100m	150m
Saemaul-ho	Geumgang	103	102.09	92.58	-	-	-
	Wonju	74	103.1	92.1	89.2	-	-
	Miho1	99	-	91.23	87.07	81.05	75.76

	Miho2	108	96.44	88.33	84.89	79.8	-
	Average	96	100.54	91.06	87.05	80.42	75.76
Mugungwha-ho	Geumgang	98	103.38	93.65	-	-	-
	Wonju	79	104.74	93.49	90.72	-	-
	Miho1	92	-	91.42	87.66	80.81	75.82
	Miho2	116	99.15	90.10	86.96	83.22	-
	Average	96	102.31	92.16	88.44	82.01	75.82
Tongil-ho	Wonju	64	104.35	93.40	90.95	-	-
	Miho2	98	101.08	91.05	86.64	85.53	-
	Average	81	102.71	92.22	88.79	85.55	-
Cargo train	Geumgang	48	103.76	92.70	-	-	-
	Wonju	60	106.74	94.24	92.24	-	-
	Miho1	61	-	91.58	87.60	82.73	77.64
	Miho2	57	96.65	90.49	86.86	83.08	-
	Average	57	102.38	92.25	88.90	82.90	77.64
The overall average		83	101.99	91.94	88.27	82.72	76.41

Table 2 : Noise levels according to measurement distance by vehicle type of steel bridges

Vehicle type	Bridge	Measurement results by distance dB(A) ΔL_1	ΔL_2	Average
Saemaul-ho	Wonju	2.90	-	2.90
	Miho Ⅰ	4.16	6.02	5.09
	Miho Ⅱ	3.44	5.09	4.26
	Average	3.50	5.55	3.99
Mugungwha-ho	Wonju	2.77	-	2.77
	Miho Ⅰ	3.76	6.85	5.30
	Miho Ⅱ	3.14	3.74	3.44
	Average	3.22	5.29	4.25
Tongil-ho	Wonju	2.45	-	2.45
	Miho Ⅱ	4.41	-	2.20
	Average	3.43	0.00	1.71
Cargo train	Wonju	2.00	-	2.00
	Miho Ⅰ	3.98	4.87	4.42
	Miho Ⅱ	3.86	3.78	3.82
	Average	3.28	4.32	3.21
The overall average	Steel bridge	3.34	4.07	3.71
Remark	$\Delta L_1 \Delta L_2$。 distance attenuation, = 25m - 50m, = 50m - 100m			

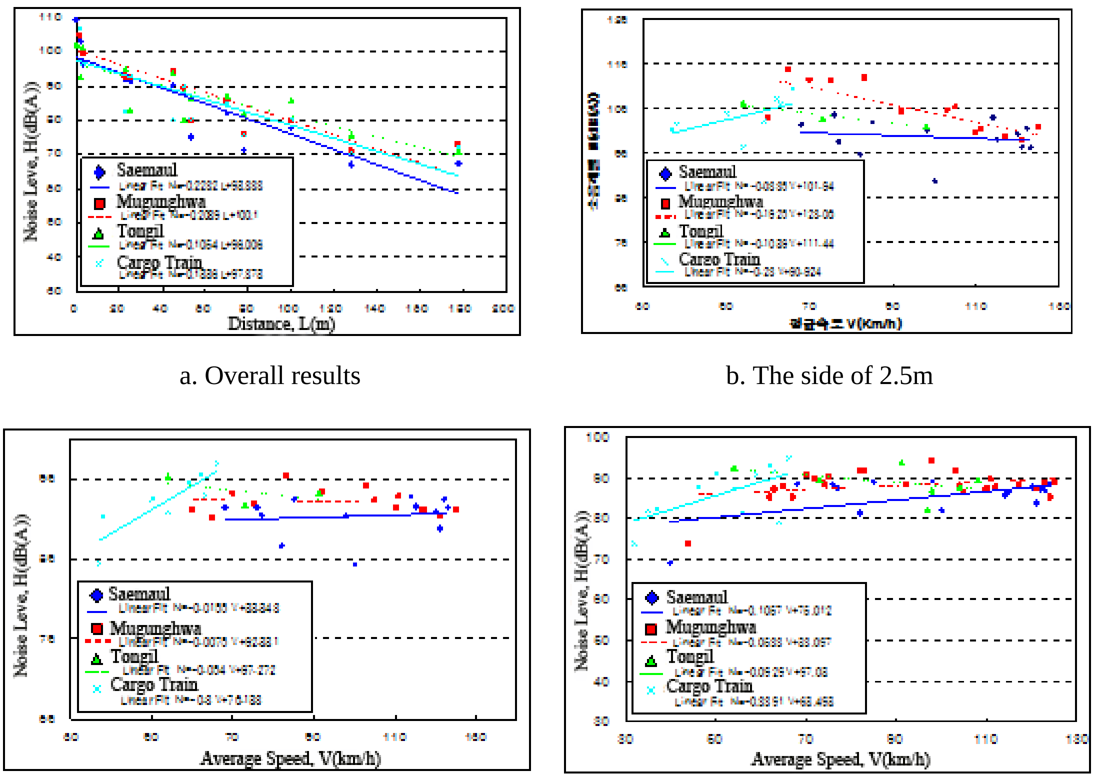
Table 3: Noise attenuation according to measurement distance by vehicle type of steel bridges

Measurement results of track 2.5m were obtained from the upper part of Geumgang 1st Bridge and Wonjucheon Bridge, and those of Mihocheon 2 from measurement at the point 2m below from the rail height of the bridge. The noise level of Mihocheon Bridge 2 turned out to be lower than that of Wonjucheon Bridge or Geumgang 1st Bridge. There was no significant difference in quantity of heat by vehicle type. Train speed on Geumgang 1st Bridge and Mihocheon 1st Bridge was found to be higher than that of Wonjucheon Bridge, but the measured noise level was biggest at the bottom of Wonjucheon Bridge due to geographical characteristics.

The average driving speed on steel bridges was 83Km/h, and the average nose level turned out to be 102dB (A) at the point of 2.5m, 92dB (A) at 25m point, 88dB (A) at 100m point, 83dB (A) at 150m point, and about 76dB (A) at 150m point. The biggest noise level was measured on Wonjucheon Bridge, which is attributed to geographical characteristics. The average noise level by vehicle type measured along the line side was almost same with an average of 102dB (A), and only Saemaul Train showed about 1dB lower level compared to others.

The average noise attenuation by distance was around 3.7dB, and the degree of attenuation increased 3.4dB from 25m to 50m away, and 4.1dB from 50m to 100m away. The width of attenuation tends to increase as the distance increases. The noise attenuation was larger on Mihocheon Bridge with soft surface of the ground than on Wonjucheon Bridge with hard surface of the ground, and the size of noise attenuation according to the surface of the ground turned out to be approximately 1～2 dB(A).

Figure 4-a shows results of the regression analysis on the noise levels by vehicle type according to measurement distance on steel bridges, and results of the regression analysis on the noise levels by vehicle type according to distance of receiving points are shown in Figure 4-b. The following equations show results of regression analysis on the noise levels by vehicle type, distance and train speed of steel bridges, and the noise prediction expression by vehicle type according to the distance of noise measurement on steel bridges is shown in Table 4.



a. Overall results

b. The side of 2.5m

c. The side of 25m

d. The side of 50m

Figure 4: Analysis on the noise levels by vehicle type according to the measurement distance on steel railway bridge

Unit: dB(A)

Distance Vehicle type	Receiving point of 2.5m	Receiving point of 25m	Receiving point of 50m	Remark
Saemaul-ho	N=-0.0335V+101.94	N=-0.0155V+88.843	N=-0.1057V+75.012	N:Noise level
Mugungwha-ho	N=-0.1925V+123.06	N=-0.0075V+92.881	N=-0.0533V+83.097	V: Speed
Tongil-ho	N=-0.1089V+111.44	N=-0.054V+97.272	N=-0.0929V+97.08	
Cargo train	N= 0.23V+90.924	N=-0.3V+76.183	N= 0.339V+68.498	

Table 4: Noise level prediction equation by distance and vehicle type according to the train speed on steel railway bridge

5. CONCLUSION

For noise prediction and identification of noise characteristics of steel bridges operated in Korea, the status of noise levels on steel railway bridge and propagation characteristics were investigated though measurement of the size of noise sources and propagation characteristics by vehicle type (Saemaul-ho, Mugungwha-ho, Tongil-ho and cargo train), train speed and distance of receiving points. An analysis on the noise sources was carried out after selecting four representative locations from measured targets. As its results, the average noise level turned out to be 102dB (A) at 2.5m point, 92dB (A) at 25m point, 88dB (A) at 50m point, 83dB (A) at 100m point, and about 76dB (A) at 150m point respectively. The average noise attenuation effects according to distance was around 3.7dB, and analysis results found that the width of attenuation tend to increase as the distance increases. In addition, the noise level prediction equation by vehicle type and distance according to the speed was proposed. In the future, it is required to conduct a comparative study of experimental and prediction equations through numerical analysis.

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